

ing to the calculations of Celoria, do not include the greater number of places within the belt of totality. It may be remembered that a calculation of the eclipse which occurred only two years later (1241 October), published by Hansen in the Transactions of the Saxon Society of Sciences, gave a total eclipse both at Erfurt and Stade near Bremen, where it is recorded to have been so observed, and hence his tables were considered satisfactory. Both eclipses may deserve further examination.

D'ARREST'S COMET.—This comet appears now to make a very close approach to the orbit of the planet Jupiter, from which circumstance it is possible that in some forty-five years from this time its elements may be entirely changed. Considerable perturbations from the attraction of this planet took place between the latter part of the year 1857 and the next period of the comet's visibility, so that by Leveau's calculations for that epoch the time of revolution had been increased sixty-eight days, the inclination diminished more than two degrees, with very material changes in the other elements. If we adopt the orbit found by Leveau for the last appearance, we have the following distances of the comet from the orbit of Jupiter at different points of heliocentric ecliptical longitude—equinox of 1872:—

In $139^{\circ} 1'$ distance	0'411...Aphelion
146 28	" 0'292...Ascending Node
150 0	" 0'189
152 0	" 0'098
153 0	" 0'085

In longitude  $153^{\circ} 10'$ , which is about the point of nearest approach, the distance between the two orbits is only 0'0841. At this point the comet's radius-vector is 5'4254, with latitude  $1^{\circ} 52' N.$ , and it is passed 873 days or 2'39 years before the arrival at perihelion. Without very sensible perturbations in the mean time, the comet and planet would encounter each other at the latter end of the year 1920, when, as noted above, an entire change of orbit might take place.

THE MINOR PLANETS.—Inquiries are occasionally received for the fullest catalogue of elements of the minor planets. Such readers as have occasion to refer to a pretty complete list, will find the latest and most authentic summary in the "Berliner Astronomisches Jahrbuch" for 1877, where the orbits of upwards of 130 of these planets are given, and in many cases from new and complete discussion. Indeed, the preparation of elements and ephemerides of the minor planets forms a speciality of the "Berliner Jahrbuch" under the superintendence of Prof. Tietjen. The labour and practical difficulty attending this work have now become very great, so much so as to require almost exclusive devotion to it of a body of computers, if accurate results for the guidance of observers are expected. Prof. Tietjen to a considerable extent ensures this. The elements are collected by him in each successive volume, the latest being found as stated above in that for 1877, published within the last few months.

#### ON THE PLAGIOGRAPH alter THE SKEW PANTIGRAPH.

I HAVE been led by the study of linkages to the conception of a new instrument, or rather a simple modification of an old and familiar one, the Pantigraph, by means of which a figure in the act of being magnified or reduced may at the same time be slewed round the centre of similitude. Some of the readers of NATURE, such possibly as my able and most ingenious friends, Messrs. George Cayley and Francis Galton, may be able to pronounce with authority how far the invention is new and whether it is likely to be found in any way useful in practice as applied to the art of the designer or engine turner. Already my invention of the Isagoniostat, or equal angle setter, which I shall take some other opportunity to communicate to this journal, has been deemed

available in practice for working automatically the train of prisms of a spectroscope.

In Fig. 1, A O B C Q represents an ordinary pantigraph. O is the fixed point, P is the tracer, and Q the correspond-

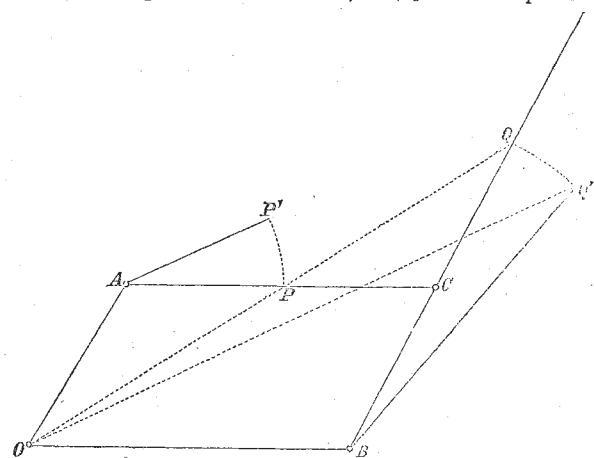


FIG. 1.

ing follower; then, as everybody knows, any curve traced out by P will be imitated by Q, and the two curves will be similarly situated in respect to O. The point of addition is the following:—

Let P be moved through any angle, P' A P round A, and Q through an equal angle Q B Q' in the opposite direction round B, and let P' and Q' be supposed to be in any manner rigidly connected with the bars A C, B C respectively. Then it admits of an easy proof that in whatever way the pointed parallelogram A O B C is deformed, O Q' will bear to O P' the constant ratio of A C to A P, and moreover the angle P' O Q' will always remain equal to the angles P' A P, Q B Q.

It follows that whilst P' is made to move upon any curve the follower Q' will trace out a similar curve altered in magnitude, and at the same time turned round the first point O.

If, as in Fig. 2, we take A D equal to A C, B E equal to

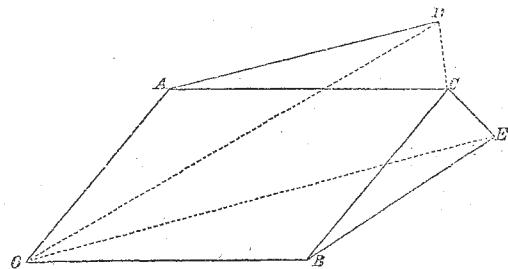


FIG. 2.

B C, and the angles CAD, CBE equal to each other, then the rays OD, OE will always remain equal and be inclined to each other at a constant angle. With this adjustment the instrument may be used to transfer a figure from one position in a sheet of drawing paper to any other position upon it, leaving its form and magnitude unaltered, but its position slewed round through any desired angle.

J. J. SYLVESTER

#### SCIENCE IN GERMANY

(From a German Correspondent.)

WHEN in 1819 Dulong and Petit measured the specific heats of some solid elements they found for each of the elements experimented upon, a very simple relation between its specific heat and its atomic weight: the product obtained by multiplying the specific heat

with the atomic weight gave a constant value, or, in other words, the atoms of all the elements experimented with have the same capacity for heat. The investigation of Regnault confirmed this law, showing that it is valid for most of the solid elements with tolerable exactness; but it should be remembered here that the specific heats of these elements must be determined at temperatures which are sufficiently below the melting points of the elements in question. Only carbon, boron, and silicon proved exceptions to this remarkably simple, natural law; for these three elements far smaller atomic heats were found. It was also found that the different allotropic modifications of these three elements possess quite different specific heats, and that none of these specific heats were in accordance with Dulong and Petit's law. Later on similar results were obtained by De la Rive and Marçet, Wüllner and Bettendorf. We must not forget to mention, for the sake of completeness, that with regard to the difference in the specific heats of the allotropic modifications of an element, Kopp has already, in 1864, stated his belief that all allotropic modifications of each element possess the same specific heat in all cases, and that the results of experiments which are contradictory to this view must be considered as caused either by a faulty method of observation or else by impurities in the substances used.

Herr Weber of Hohenheim has succeeded lately in proving the validity of Dulong-Petit's law, also for carbon, boron, and silicon; his experiments were made with Bunsen's ice-calorimeter. In order to heat the substances experimented upon to a series of temperatures below red heat, oil baths were used, and various temperatures between  $0^{\circ}$  and  $300^{\circ}$  C. were applied; in order to cool them, solid carbonic acid and a cold mixture, consisting of one part of snow and  $\frac{1}{3}$  part of common salt, were employed. All these temperatures were read off directly from an ordinary air-thermometer. For higher temperatures (between  $500^{\circ}$  and  $1000^{\circ}$ ) an indirect method was made use of, which allowed of the determination of the temperatures by means of the indications of the calorimeter. This indirect method is based on the correctness of Pouillet's determinations (published in 1836) of the quantity of heat which a certain unity of weight of platinum requires to become heated from temperature  $T_0$  to  $T$ . (These determinations are given by Pouillet for the interval  $T = 0^{\circ}$  to  $T = 1200^{\circ}$  C.) The results which Herr Weber obtained may be stated as follows:—The specific heats of carbon, boron, and silicon increase regularly as the temperature rises, from the lowest obtainable degrees of temperatures upwards, and finally remain nearly constant after a certain degree has been reached. The nature of the function, which expresses the dependence of the specified heat  $\gamma$  from the temperature  $T$ , seems to be the same for all the three elements, and to possess the following formula:—

$$\gamma = A - \frac{B(1 + hT)}{e^{qT}}$$

where  $A$ ,  $B$ ,  $q$  and  $h$  express constant positive values, and  $A > B$ ,  $q > h$ , and also  $T$  is the temperature counted upwards from the absolute zero.

The temperature from which the specific heat of carbon remains nearly constant is somewhere near  $600^{\circ}$  C., and it is immaterial whether the carbon is in the form of diamond or in that of graphite. From red heat upwards this element shows no greater variability in its specific heat than the other elements which follow Dulong-Petit's law. (At lower temperatures, however, for instance when the temperature rises from  $-50^{\circ}$  C. to  $+600^{\circ}$ , its specific heat increases sevenfold). The specific heats of graphite and diamond are perfectly identical above  $600^{\circ}$  C., if we neglect small differences, which do not exceed the numerical value of the specific heat by more than  $0.5$  to  $2$  per cent. The specific heats of graphite, of the dense amorphous coal, and of the porous charcoal, are within the interval from  $0^{\circ}$  to  $225^{\circ}$  C. per-

fectly identical from degree to degree. Thus all opaque modifications of carbon (the graphitic, dense and porous forms) have the same specific heat. We may say that below red heat, from a *thermal* point of view, there are only two different allotropic modifications of carbon, the transparent and the opaque one. The specific heats of these modifications differ all the more the lower their respective temperatures; if the latter rise, they approach each other steadily and become identical at about  $600^{\circ}$ . Above red heat there are no different allotropic modifications of carbon with regard to specific heat; from that point in the scale of temperature, where the *optical* difference of the two modifications of carbon ceases, the *thermal* difference ceases also. Kopp's view as quoted above is thus completely affirmed.

With regard to the specific heat of crystallised silicon, it approaches (analogous to the specific heat of carbon) as the temperature rises a nearly constant limit, which is reached at about  $200^{\circ}$ , after having passed through highly variable values. At that point of the scale of temperature the variability of the specific heat of silicon is no greater, than that of the metallic elements. With regard to the experiments with crystallised boron, it has been found that within the interval of temperature from  $-80^{\circ}$  to  $+260^{\circ}$  C. the specific of this element behaves in a manner which is perfectly analogous to the specific heats of opaque and transparent modifications of carbon. This great coincidence in the behaviour of the specific heats of both elements justifies the supposition that also the specific heat of boron in a rising temperature approaches a nearly constant limit, and that this lies somewhere near a moderate red heat. Unfortunately, Herr Weber could not prove the correctness of this supposition by direct experiments through want of sufficient material.

The nearly constant final values, which are reached as the temperature rises by the specific heats of both carbon and crystallised silicon, were found to be, in round numbers—

For carbon	...	...	...	...	...	...	...	0.46
"	crystallised silicon	...	...	...	...	...	...	0.205

For crystallised boron, as we have said before, this final value could not be experimentally determined, but from the measurements that were made, and from the nature of the function which represents the specific heat of boron in its dependence upon temperature, we may conclude that this final value lies somewhere near  $0.5$ . The atomic weights of the three elements, as found by the determination of their vapour densities, are—

Carbon	...	...	...	...	...	...	...	12
Silicon	...	...	...	...	...	...	...	28
Boron	...	...	...	...	...	...	...	11

The products of these figures when multiplied by the specific heats of these elements as mentioned above, give for their atomic heats the values—

5.5	...	...	5.8	...	...	5.5
-----	-----	-----	-----	-----	-----	-----

i.e., values which closely correspond to the atomic heats of metals and the other solid metalloids.

Hence it follows that beyond a certain temperature, carbon, silicon, and boron also follow Dulong and Petit's law, and continue to do so as long as the temperature rises. Dulong and Petit's law has thus become one without exceptions. The wording of this law ought, however, to be somewhat different to what it has been up till now; the following would, perhaps, be best:—

"The specific heats of the solid elements vary according to temperature; but for each element there is a point  $T_0$  in the scale of temperature beyond which, as the temperature  $T$  rises, the variability of the specific heat becomes insignificant. The product obtained by multiplication of the atomic weight with that value of the specific heat which belongs to the temperatures  $T > T_0$ , is a nearly constant value for all solid elements, and lies between 5.5 and 6.5."

S. W.